

# Xuanhe Zhao

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## Degree and Education

PhD in Mechanical Engineering, Harvard University (Advisor: Prof. Zhigang Suo)	11/2009
MS in Mechanical Engineering, Harvard University	09/2008
MASc in Materials Engineering, The University of British Columbia	07/2006
BE in Electrical Engineering, Tianjin University	07/2003

## Experience

Associate Professor with Tenure, Department of Mechanical Engineering and Department of Civil and Environmental Engineering (joint), MIT	05/2017-Present
Associate Professor without Tenure, Department of Mechanical Engineering and Department of Civil and Environmental Engineering (joint), MIT	01/2015-05/2017
Assistant Professor, Department of Mechanical Engineering and Department of Civil and Environmental Engineering (joint), MIT	09/2014-01/2015
Visiting Scientist, Department of Mechanical Engineering, MIT	05/2014-09/2014
Assistant Professor, Department of Mechanical Engineering and Materials Science, Duke University	07/2010-09/2014
Postdoctoral Fellow in Biomedical Engineering, Harvard University (Advisor: Prof. David Mooney)	07/2009-07/2010

## Selected Awards and Honors

Young Investigator Medal, Society of Engineering Science	07/2017
Young Scientist Award, The Adhesion Society	02/2017
Extreme Mechanics Letters Young Investigator Award, Elsevier	12/2015
Robert N. Noyce Career Development Professorship, MIT	07/2015

Journal of Applied Mechanics Award, ASME	02/2015
d'Arbeloff Career Development Chair, MIT	07/2014
Hunt Faculty Scholar, Duke University	07/2014
2014 Young Investigator Program Award (YIP), Office of Naval Research	04/2014
Arthur K. Doolittle Award, ACS Polymeric Materials Science and Engineering Division	02/2014
2013 US Frontiers of Engineering Symposium, National Academy of Engineering	09/2013
Invited lecturer, Gordon Research Conference on the Science of Adhesion	07/2013
Faculty Early Career Development (CAREER) Award, National Science Foundation	12/2012
Early Career Researchers Award, AVS Biomaterial Interfaces Division	11/2012
2012 ICTAM Travel Fellowship Grant Award, US National Committee on Theoretical and Applied Mechanics	08/2012
Haythornthwaite Research Initiation Grant Award, American Society of Mechanical Engineers	11/2011
NSF Travel Fellowship for Workshop on Mechanics of Soft Materials	03/2010
MRS Graduate Student Award Final List	04/2009
Chinese Government Award for Outstanding Self-financed Students Abroad	11/2008
AAM Founder's Prize, American Academy of Mechanics	03/2008
Winston Chen Graduate Fellowship, Harvard University	09/2006; 09/2007
John S Nadeau Memorial Scholarship, The University of British Columbia	11/2005
Outstanding Graduation Thesis, Tianjin University	07/2003

## Professional Activity

Associate Editor in Chief, Acta Mechanica Sinica	2015-Present
Editorial Board, Scientific Reports	2015-Present
Editor, Journal Club of imechanica.org	2013-2014
Editorial Board, International Journal of Applied Mechanics	03/2012-Present
Elected Chair, Technical Committee on Soft Materials, American Society of Mechanical Engineers	11/2012-Present
Review Panel, National Science Foundation	2012-2014
Proposal Reviewer, Army Research Office	2011

Reviewer for Nature, Nature Series, PNAS, Journal of the Mechanics of Physics and Solids, International Journal of Solids and Structures, International Journal of Applied Mechanics, Journal of Applied Mechanics, Physical Review Letters, Langmuir, Soft Matter, Advanced Materials, Smart Materials and Structures, International Journal of Non-Linear Mechanics, Macromolecules, Journal of Materials Research.

2009-Present

## Research Interests

Zhao group's current research goal is to understand and design soft materials that possess unprecedented properties such as extremely tough and strong, ultrasensitive to stimuli, mutable and programmable, biocompatible and bioabsorbable; and to explore their extraordinary functions in technologies such as wearable and biointegrated electronics, antifouling and water treatment, energy harvesting and storage, soft robotics and machines. In order to achieve this goal, we are advancing fundamental knowledge on interfaces between solid mechanics, soft materials, and bioinspired design. Representative research achievements include:

- Formulate a multiscale theoretical framework for judicious design of unconventional polymer networks to give extremely robust hydrogels, hydrogel adhesives and hydrogel-solid hybrids. Create a set of hydrogels with diverse biopolymers that contain 90% water but achieve fracture toughness over  $9000 \text{ Jm}^{-2}$ , among the world's toughest synthetic hydrogels. Create tough bonding of hydrogels to diverse nonporous solid materials that is transparent and conductive and achieves interfacial toughness of  $1500 \text{ Jm}^{-2}$ , among world's toughest synthetic hydrogel bondings. 3D print hydrogel electronics and devices that are robust, biocompatible and capable of sensing, lighting and controlled drug delivery.
- Develop a phase-diagram approach to predict various modes of surface instabilities. Invent the world's first method to reversibly crumple and unfold large-area graphene and nanosheets by harnessing surface instabilities, which enables broad applications of graphene in coatings, optical devices and energy storage.
- Experimentally discover and theoretically explain the *electro-creasing*, *electro-cratering*, and *electro-cavitation* instabilities, which are critical failure modes for dielectric polymers under voltages used in broad and important applications ranging from insulating cables to polymer capacitors and actuators.

## Publication and Citation

**Publication.** >90 papers in referred journals including *Nature*, *Nature Materials*, *Nature Communications*, *PNAS*, *Science Advances*, *PRL*, *Advanced Materials*, *Advanced Functional Materials*, *Advanced Healthcare Materials*, *Nanoletters*, *JMPS*, *IJSS*, *JAM* et al.

**Full list.** <http://www.web.mit.edu/zhaox/www/publication.html>

**ISI Web of Knowledge.** <http://www.researcherid.com/rid/B-1532-2008> (H-index=35)

**Google Scholar.** [http://scholar.google.com/citations?user=4bHLr\\_IAAAAJ](http://scholar.google.com/citations?user=4bHLr_IAAAAJ) (H-index=43)

**Recent papers.**

1. Shaoting Lin, Yunwei Mao, Raul Radovitzky, Xuanhe Zhao\*, Instabilities in Confined Elastic Layers under Tension: Fringe, Fingering and Cavitation, *Journal of the Mechanics and Physics of Solids*, DOI: 10.1016/j.jmps.2017.05.011 (2017)
2. Yunwei Mao, Shaoting Lin, Xuanhe Zhao, Lallit Anand\*, A large deformation viscoelastic model for double-network hydrogels, *Journal of the Mechanics and Physics of Solids*, 100, 103–130 (2017)
3. Xinyue Liu, Tzu-Chieh Tang, Eleonore Tham, Hyunwoo Yuk, Shaoting Lin, Timothy K. Lu\*, Xuanhe Zhao\*, Stretchable Living Materials and Devices with Hydrogel-Elastomer Hybrids Hosting Programmed Cells, *Proceedings of the National Academy of Sciences*, 114, 2200–2205 (2017)
4. W. Wang, L. Yao, C. Y. Cheng, T. Zhang, H. Atsumi, G. Wang, L. Wang, O. anilionyte, H. Steiner, J. Ou, K. Zhou, C. Wawrousek, K. Petrecca, R. Karnik, X. Zhao\*, D. I. C. Wang\*, H. Ishii\*, Harnessing the Hygroscopic and Biofluorescent Behaviors of Genetically-Tractable Microbial Cells to Design Bio-hybrid Wearables, *Science Advances*, 3, e1601984 (2017)
5. Hyunwoo Yuk, Shaoting Lin, Chu Ma, Mahdi Takaffoli, Nicholas X. Fang, Xuanhe Zhao\*, Hydraulic hydrogel actuators and robots optically and sonically camouflaged in water, *Nature Communications*, 8, 14230 (2017)
6. Shaoting Lin, Tal Cohen, Teng Zhang, Hyunwoo Yuk, Rohan Abeyaratne, Xuanhe Zhao\*, Fringe Instability in Constrained Soft Elastic Layers, *Soft Matter*, 12, 8899 (2016)
7. Hyunwoo Yuk, Teng Zhang, German Alberto Parada, Xinyue Liu, Xuanhe Zhao, Skin-Inspired Hydrogel-Elastomer Hybrids with robust interfaces and functional microstructures, *Nature Communications*, 7, 12028 (2016)
8. Hyunwoo Yuk, Teng Zhang, Shaoting Lin, German Alberto Parada, Xuanhe Zhao, Tough Bonding of Hydrogels to Diverse Nonporous Surfaces, *Nature Materials*, 15, 190-196 (2016)
9. Jingjing Guo, Xinyue Liu, Nan Jiang, Ali K. Yetisen, Hyunwoo Yuk, Changxi Yang, Ali Khademhosseini, Xuanhe Zhao, and Seok-Hyun Yun\*, Highly Stretchable, Strain Sensing Hydrogel Optical Fibers, *Advanced Materials*, 28, 10244 (2016)
10. Mark A. Gonzalez, Joseph Simon, Ali Ghoorchian, Zachary Scholl, Shaoting Lin, Michael Rubinstein, Piotr Marszalek, Ashutosh Chilkoti, Gabriel P. López, and Xuanhe Zhao, Strong, tough, stretchable and self-adhesive hydrogels from intrinsically unstructured proteins, *Advanced Materials*, 1604743 (2017) DOI: 10.1002/adma.201604743
11. Qiming Wang, Gregory R. Gossweiler, Stephen L. Craig, Xuanhe Zhao, Mechanics of Mechanochemically Responsive Elastomers, *Journal of the Mechanics and Physics of Solids*, 82, 320 (2015).
12. Shaoting Lin#, Hyunwoo Yuk#, Teng Zhang#, Hyunwoo Koo, Cunjiang Yu and Xuanhe Zhao, Stretchable Hydrogel Electronics and Devices, *Advanced Materials*, DOI: 10.1002/adma.201504152 (2015) (#: Equal contribution)
13. Nathaniel Huebsch, Evi Lippens, Kangwon Lee, Manav Mehta, Christopher Madl, Maria Xu, Xuanhe Zhao, Ovijit Chaudhuri, Catia Verbeke, Woo Seob Kim, Karen Alim, Akiko Mammoto, Donald Ingber, Georg Duda, David Mooney, Matrix Elasticity Controls Bone Formation by Transplanted Stem Cells, *Nature Materials*, 14, 1269–1277 (2015)
14. Sungmin Hong#, Dalton Sycks#, Hon Fai Chan#, Shaoting Lin, Gabriel P. Lopez, Farshid Guilak, Kam W. Leong, and Xuanhe Zhao, 3D Printing of Highly Stretchable and Tough Hydrogels into Complex, Cellularized Structures, *Advanced Materials*, 27, 4035 (2015)
15. A Ghoorchian, J.R. Simon, B. Bharti, W. Han, X. Zhao, A. Chilkoti, G.P. López, Bio-inspired Reversibly-Crosslinked Hydrogels Comprising Polypeptide Micelles Exhibit Enhanced Mechanical Properties, *Advanced Functional Materials*, DOI: 10.1002/adfm.201500699 (2015)
16. Qiming Wang, Xuanhe Zhao, A Three-Dimensional Phase Diagram of Growth-Induced Surface Instabilities, *Scientific Reports*, 5, 8887 (2015)
17. Xuanhe Zhao, Multi-scale Multi-mechanism Design of Tough Hydrogels: Building Dissipation into Stretchy Networks, *Soft Matter*, 10, 672 (2014)
18. Qiming Wang, Gregory R. Gossweiler, Stephen L. Craig, Xuanhe Zhao, Cephalopod-inspired Design of Electro-mechano-chemically Responsive Elastomers for On-demand Fluorescent Patterning, *Nature Communications*, 5, 4899 (2014)

19. Nathaniel Huebsch#, Cathal Kearney#, Xuanhe Zhao#, Jaeyun Kim, Christine Cezar, Zhigang Suo and David J Mooney, Ultrasound-triggered disruption and self-healing of reversibly-crosslinked hydrogels for drug delivery and enhanced chemotherapy. *Proceedings of the National Academy of Sciences*, 111, 9762-9767 (2014) (#: Equal contribution).
20. Jianfeng Zang, Seunghwa Ryu, Nicola Pugno, Qiming Wang, Qing Tu, Markus J. Buehler, Xuanhe Zhao, Multifunctionality and Control of the Crumpling and Unfolding of Large-Area Graphene, *Nature Materials*, 12, 321 (2013)
21. I-Chien Liao, Franklin T. Moutos, Bradley T. Estes, Xuanhe Zhao, Farshid Guilak, Composite three-dimensional woven scaffolds with interpenetrating network hydrogels to create functional synthetic articular cartilage, *Advanced Functional Materials*, 47, 5833-5839 (2013)
22. Phanindhar Shivapooja#, Qiming Wang#, Beatriz Orihuela, Daniel Rittschof, Gabriel P. López, Xuanhe Zhao, Bioinspired Surfaces with Dynamic Topography for Active Control of Biofouling, *Advanced Materials*, 25, 1430 (2013) (#: Equal contribution).
23. Qiming Wang, Zhigang Suo, Xuanhe Zhao, Bursting Drops in Solid Dielectrics Caused by High Voltages, *Nature Communications*, 3, 1157 (2012).
24. Jeong-Yun Sun, Xuanhe Zhao, Widusha R. K. Illeperuma, Ovijit Chaudhuri, Kyu Hwan Oh, David J. Mooney, Joost J. Vlassak, Zhigang Suo, Highly stretchable and tough hydrogels, *Nature*, 489, 133 (2012)
25. Xuanhe Zhao, A Theory for Large Deformation and Damage of Interpenetrating Polymer Networks, *Journal of the Mechanics and Physics of Solids*, 60, 319 (2012)
26. Jianfeng Zang, Xuanhe Zhao, Yanping Cao, John W. Hutchinson, Localized Ridge Wrinkling of Stiff Films on Compliant Substrates, *Journal of the Mechanics and Physics of Solids*, 60, 1265 (2012)
27. Qiming Wang, Mukarram Tahir, Jianfeng Zang, and Xuanhe Zhao, Dynamic Electrostatic Lithography: Multiscale On-demand Patterning on Large-Area Curved Surfaces, *Advanced Materials*, 24, 1947 (2012)
28. Qiming Wang, Lin Zhang, Xuanhe Zhao, Creasing to Cratering instability in polymers under ultrahigh electric fields, *Physical Review Letters*, 106, 118301 (2011)
29. Xuanhe Zhao, Jaeyun Kim, Christine Cezar, Nathaniel Huebsch, Kangwon Lee, Kamal Bouhadir, and David Mooney, Active Scaffolds for On-demand Drug and Cell Delivery, *Proceedings of the National Academy of Sciences*. 108, 67 (2011).
30. Xuanhe Zhao and Zhigang Suo, Theory of dielectric elastomers capable of giant deformation of actuation, *Physical Review Letters* 104, 178302 (2010)

### **Invited/Keynote Talks**

**Full list.** [http://www.web.mit.edu/zhaox/www/publication.html#invited\\_talk](http://www.web.mit.edu/zhaox/www/publication.html#invited_talk)

### **Students and Postdoctoral Fellows Supervised**

**Full list.** <http://www.web.mit.edu/zhaox/www/member.html>

### **Selected Award and Honor of Zhao's Students and Postdoctoral Fellows**

Shaoting Lin, Den Hartog Travel Award in Mechanics, Department of Mechanical Engineering, MIT	11/2015
Jianfeng Zang, MRS Best Poster Award, MRS	12/2014
Qiming Wang, MRS Graduate Student (Silver) Award, MRS	12/2014

Changyong Cao, Best Poster Award, The 6th Annual Triangle Soft Matter Workshop	05/2014
Jianfeng Zang, 1000-Young-Talent Award, Chinese Government	05/2014
Jianfeng Zang, Kewaunee Postdoctoral Achievement Award, Duke Center for Biomolecular and Tissue Engineering	03/2014
Changyong Cao, 2013 Mahato Memorial Image Contest first place, Duke University	11/2013
Qiming Wang, Haythornthwaite Foundation Student Travel Award, ASME Applied Mechanics Division	10/2013
Changyong Cao, Best Visualization & Images of Poster Award, Duke MEMS	09/2013
Changyong Cao, Best Poster Award 2nd place, The 5th Annual Triangle Soft Matter Workshop	05/2013
Changyong Cao, Travel Award, The 12th U.S. National Congress on Computational Mechanics.	04/2013
Qiming Wang, Kewaunee Student Achievement Award, Duke Center for Biomolecular and Tissue Engineering	04/2013
Qiming Wang, NSF-PACAM fellowship, 2013 PACAM conference	03/2013
Qiming Wang, Second Place in the 2010 ASME AMD Student Paper Competition, ASME Applied Mechanics Division	11/2011
Qiming Wang, IMECE 2011 Student travel award, ASME 2011 International Mechanical Engineering Congress and Exposition	11/2011
Qiming Wang, Best graduate student poster award 1st Prize, Duke MEMS Graduate Student Retreat	10/2011